UNIVERSITI TEKNOLOGI MARA

Hybrid Evolutionary Programming-Artificial Neural Network-Based Lightning Prediction System

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Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Teknologi MARA. It is original and is the result of my own work, unless otherwise indicated or acknowledged as referenced work. This topic has not been submitted to any other academic institution or non-academic institution for any other degree or qualification.

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Abstract

This project presents the development of hybrid evolutionary programming (EP) and artificial neural network (ANN) prediction system for lightning occurrence based on historical lightning and meteorological data from a Malaysian environment. It involved the development of ANN design and embedding EP optimization technique for optimizing selected ANN parameters in order to improve the system's generalization capability. ANN, an intelligent machine learning technique, is inspired by the way our biological nervous systems process information. With the ability to learn by example and do tasks based on training experience, it is profoundly suitable for pattern recognition and forecasting tasks. Due to ANN heuristics nature, though, the process of finding suitable network architectures could be arduous and time-consuming. It highly depends on expert experience and is a tedious trial and error process. There is also no systematic way to design the optimal architecture for a given task automatically. For that reason, an efficient optimization technique such as EP was employed in the study to find the best ANN architectures systematically and perform lightning prediction accurately with less computation time. Comparative study conducted between determining ANN parameters heuristically and by using EP revealed that hybrid EP optimization technique with the ANN produced better results for the ANN in terms of its R-value and computational time. The most significant advantage of using EP optimization technique is that it provides a structured and automatic way for obtaining optimal values of the ANN parameters, while using heuristic technique, each possible value had to be tried one by one manually before the optimal values could be found. As a result, the developed lightning prediction system is able to generalize well when presented with new sets of input data. Consequently, prediction of the lightning occurrence can be successfully done.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Lightning could cause destruction in many forms. Either directly or indirectly, the effects could be devastating and fatal. Lightning protection system, though installed, does not necessarily guarantee total protection. People and structures are still exposed to the danger of lightning resulting in the need for lightning prediction system.

In the aerospace industry, lightning strikes could lead to loss of life during space shuttle launches and have caused damage reaching millions of dollars. In 1969, Apollo 12 Saturn V was stricken shortly after take-off from Kennedy Space Center in the United States, causing momentarily failure of vital electronic instruments before returning to normal [1]. Atlas-Centaur 67 rocket and its communication satellite payload was destroyed in 1987 by a lightning strike causing a loss of some $160 millions (as reported in [1]). There is also danger to fueling crew and other ground assets leading responsible bodies to consider lightning prediction as a means of reducing lightning threat.

Similarly, losses due to lightning strikes are also costly in the aviation industry and especially inconvenient for passengers. All kinds of ground-support services such as aircraft refueling, aircraft maintenance, baggage handling and catering are affected by impending lightning. In order to minimize service interruptions, accurate lightning prediction system should be put in place so that the airlines company could make sound decisions in arranging its workforce.